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ABSTRACT

Psychology stands in the paradoxical position of adhering to outmoded conceptions of knowledge while being looked upon as providing an instrument for a more adequate conception. Cognitive psychology's schema theory provides a conceptual equivalent to Kuhn's learned perception of similarity and the related notion of exemplar, which serves to exemplify adequate conceptions of knowledge within the philosophy of science. Both cognitive psychology and Kuhn's philosophy of science share similar conceptions of cognitive organization. Specifically, schema theory's empirical offspring provide a validation mechanism for Kuhn's notion that members of a scientific community solve problems with which they are confronted by learning, through socialization, to see them as problem categories or schemata. This convergence of the philosophy of science with cognitive psychology instantiates the epistemological trend toward understanding the limitations and validity of scientific evidence through an understanding of the limitations and validity of the scientist. (Author/BL)

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The Convergence of Kuhn and Cognitive Psychology

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Running head: KUHN AND COGNITIVE PSYCHOLOGY

Abstract

Although psychology has been criticized for adhering to outmoded conceptions of knowledge (e.g., logical positivism), the assertion is made that at least one branch of psychology, namely cognitive psychology, is in the position to collaborate with contemporary philosophy of science. Kuhn's 'learned perception of similarity" and the related notion of exemplar, which serve to exemplify adequate conceptions of knowledge within the philosophy of science, are shown to converge with cognitive psychology's schema theory. In this way, the schema theory's empirical offspring provide a validation mechanism for Kuhn's notions and thus provide a richer understanding of the scientific enterprise. This convergence is seen as instantiating an epistemological trend towards understanding the limitations and validity of scientific evidence through an understanding of the limitations and validity of the scientist.

The Convergence of Kuhn and Cognitive Psychology

The methodological and philosophical autonomy of psychology has been in question since its claim to independence. This conformity to exogeneous principles grows largely out of psychology's early dependency on the more established natural sciences (e.g., physics) and philosophy of science (e.g., logical positivism) for its sense of direction. However, Koch (1964) notes that within the past two decades these very same disciplines on which psychology modeled itself appear to be "working toward, or inviting into existence, a redefinition of knowledge based on an empirical analysis of inquiry of a sort which must largely depend on psychological modes of analysis" (p. 5). In this way, psychology stands in the paradoxical position of simultaneously adhering to outmoded conceptions of knowledge while being looked upon, by the rest of the scholarly community, as providing an instrument for a more adequate conception. But while mainstream psychology has remained anchored to its antiquated past, other disciplines, such as the philosophy of science, have stepped into the forefront of this new era by characterizing science descriptively (i.e., how science is practiced) rather than normatively (i.e., how science ought to be practiced). This is to say philosophers of science, in describing their enterprise, have come to acknowledge the psycho-social components of those who practice it, thus leading to a more adequate conception of the field. The arrival of Thomas S.

Kuhn's essay, The Structure of Scientific Revolutions, as well as his subsequent works (1970a, 1970b, 1977), exemplify, via a psycho-social analysis of the scientific community, this shift away from a normative analysis of science toward a descriptive one.

Hence, it would appear that psychology, by clinging to its primordial past, is destined once again to fall behind in the active pursuit of an adequate conception of knowledge, one which, at least in the philosophy of science, is ironically emphasizing the psychological makeup of the scientist. But perhaps all is not as it seems. For if one looks to the methodological and epistemological fringes of psychology one may see an emerging discipline, known as Cognitive Science, of which cognitive psychology is a part. While the scope of this paper precludes a discussion of the precise methodological and epistemological differences which separate this branch of psychology from the mainstream, the primary focus of this paper will center on the assertion that cognitive psychology is in the position to collaborate with contemporary philosophy of science, by virtue of adhering to a contemporary conception of knowledge, that is, if Kuhn's notion of the scientific enterprise is viewed as instantiating a contemporary conception of knowledge within the philosophy of science.

One account of Kuhn's psycho-social or descriptive analysis involves the cognitive apparatus of a given scientific community.

Any account of the cognitive apparatus of a scientific community may reasonably be asked to tell us something about the way in

> which the groups members, in advance of directly relevant empirical evidence, identify the special formalism appropriate to a particular problem, especially to a new problem (Kuhn, 1977, p. 301).

Kuhn refers here to his notion of a "learned perception of similarity", a process which is implemented in the formulation of new problem solutions from older established problem solutions (i.e., exemplars).

In cognitive psychology, the schema theory, as outlined by Rumelhart and Ortony (1977) and Rumelhart (1980), as well as some empirical investigations in light of this theory (Hinsley, Hayes, and Simon, 1978; Chi, Feltovich, and Glaser, 1980), not only absorbs Kuhn's "learned perception of similarity" and the related notion of exemplars and serves to validate it, but also leads the philosophy of science to a greater understanding of the scientific enterprise. Thus, it is the aim of this paper to show that cognitive psychology is on a par, conceptually, with contemporary philosophy of science, in that both are making the same sort of claims about the human organism. In addition, this paper will seek to broaden Kuhn's conception of how scientists solve new problems (i.e., "learned perception of similarity") and the relationship this holds with the socialization of an individual into a scientific community. The format, then, will first be to provide a clearer description of Kuhn's "learned perception of similarity" followed by cognitive psychology's conceptual equivalent,

the schema theory. Some practical applications of this theory, as it pertains to algebra word problems and physics problems, will also be presented.

Kuhn's Notion of a "Learned Perception of Similarity"

In 1962, Kuhn presented a unique interpretation of the history and philosophy of science in his essay, The Structure of Scientific Revolutions. This interpretation centered around the concept of paradigm, which denotes a refined definition of the methodology, problem field, and standards for solving the problems which the paradigm acknowledges as acute. In addition, the acceptance of a single paradigm signals the maturity of a scientific community such that communication between members, their judgments on professional matters, and the community's goals are rendered unproblematic. In his more recent essays (1970a, 1970b, 1977), Kuhn articulates the relationship between the scientific community and his notion of paradigm. For example, in the postscript of his revised edition of The Structure of Scientific Revolutions, Kuhn distinguishes two different senses of the term paradigm.

> On the one hand, it stands for the entire constellation of beliefs, values, techniques, and so on shared by the members of a given community. On the other, it denotes one sort of element in that constellation, the concrete puzzle solutions, which employed as models or examples, can replace explicit rules as a basis for the solution of the remaining puzzles of normal

science (Kuhn, 1970a, p. 175).

This latter sense of 'paradigm' is fundamental to Kuhn's notion of a "learned perception of similarity." As hinted at in the introduction, this process is the primary means by which the solution of a new problem is arrived at, e.g., by perceiving the novel problem as like an older, more established one. More specifically, this "learned perception of similarity" entails that a given scientific community comes to agree on a particular formulation of a symbolic generalization appropriate to confronting a new problem.

In Kuhn (1977), symbolic generalizations "are those expressions, deployed without question by the group, which can readily be cast in some logical form like $(x)(y)(z)\ \emptyset\ (x,y,z)$" (p. 297). However, in science, these generalizations are flexible in nature such that "they are not so much generalizations as generalization-sketches, schematic forms whose detailed symbolic expression varies from one application to the next" (Kuhn, 1977, p. 299). For example, as Kuhn (1977) points out, the symbols f, =, m, and a may appear as $mg = md^2s/dt^2$ for the problem of free fall, or as $mg\ Sin\emptyset = md^2s/dt^2$ for the simple pendulum. Hence, because these generalizations fluctuate in accordance with the context in which they will be applied, in addition to the notion that there exists within a paradigm exemplary problems which provide the various contexts, the discerning criterion for the unproblematic application of symbolic generalizations is that the members of a scientific community learn to perceive "the

context" of a novel problem in an unproblematic fashion. Such a process, as one has probably guessed, is implemented in what Kuhn refers to as a "learned perception of similarity." Furthermore, this process is acquired early in scientific training, as part of becoming socialized into a particular scientific community. Using an analogy, Kuhn describes this scientific socialization as follows:

> Father points to a bird, saying, "Look, Johnnny, there's a swan." A short time later Johnny himself points to a bird, saying, "Daddy, another swan." He has not yet, however, learned what swans are and must be corrected: "No, Johnny, that's a goose." Johnny's next identification of a swan proves to be correct, but his next "goose" is, in fact, a duck, and he is again set straight. After a few more such encounters, however, each with its appropriate correction or reinforcement, Johnny's ability to identify these waterfowl is as great as his father's (Kuhn, 1977, p. 309).

In its most fundamental form, the socialization of a "learned perception of similarity" entails the processing of sensory stimuli into bits of data (the elements of experience) which the community renders unproblematic. From here, the data are processed into similarity or like sets (e.g., ducks are seen to be different from swans and likewise from geese). Furthermore, this categorization proceeds prior to any logical or psychological criteria such as "all swans are white." In this way, the student of science is programmed,

by his/her respective community, to process new problems into sets of similar problems (i.e., exemplars) prior to implementing logical or psychological criteria such as similar solution formulations. "Once that likeness or analogy has been seen, only manipulative difficulties remain" (Kuhn, 1977, p. 305).

In short, Kuhn has postulated that the members of a scientific community solve the problems which they are confronted by learning, via socialization, to see them as like problem categories which have already been established within the community. In addition, this "learned perception of similarity" proceeds prior to any logical or psychological analysis of the problem (i.e., prior to formulating the problem for solution). Cognitively speaking, then, Kuhn is suggesting that an individual can distinguish like and unlike problems. In other words, each problem is not seen as being unique, but as belonging to a class of similar problems. In addition, this categorization must precede any criterion of similarity such as similar solution formulations. Finally, Kuhn asserts that this cognitive processing is consistent across members of the scientific community, and that this consistency is achieved through socialization. But while Kuhn makes bold statements about the cognitive apparatus of the scientific enterprise, he does little to confront these assertions directly (e.g., empirical psychological experimentation). Rather, his technique has been indirect, e.g., the history of science. Furthermore, he seems unaware of the similarities between his "learned perception

of similarity" (and the related notion of exemplars) and the development within cognitive psychology of the schema theory. Thus, the remaining task of this paper will be to point out these similarities and then, by empirical analyses, to enrich Kuhn's assertions.

Schema Theory

The history of schema theory, say Rumelhart et al. (1977), can be traced from Kant's Critique of Pure Reason. In its present form, which differs little from Kant, the schema theory constitutes a theory of knowledge, or rather, "how knowledge is represented" and "how that representation facilitates the use of knowledge in particular ways" (Rumelhart, 1980, p. 34). More specifically, the schema theory states that knowledge is organized according to units. These units, in turn, represent schemata which provide the prototypical meaning for the generic concepts of human experience.

> A schema, then, is a data structure for representing the generic concepts stored in memory. There are schemata representing our knowledge about all concepts: those underlying objects, situations, events, sequences of events, actions, and sequences of actions. A schema contains as part of its specification, the network of interrelations that is believed to normally hold among the constituents of the concept in question (Rumelhart, 1980, p. 34).

Thus, in the same way that Kuhn's notion of an exemplar serves as a model in a particular scientific community for the solution of

certain "similar" problems, so the theory of schemata serves as a model for the comprehension of human experience. In other words, exemplars may be thought of as providing the problem categories to which the remaining problems within a scientific community must be fitted. Similarly, but in a broader context, schemata provides the conceptual categories to which the human organism must refer his/her daily experience. But whereas problems which do not conform to a scientific community's arsenal of exemplars are likely to be anomalous and uninterpreted, schemata have the theoretical capacity to undergo modification (e.g., become more general or more concrete) and to be restructured (e.g., the creation of new schemata from older ones) to account for anomalous experiences. Such a conflict, between the nature of schemata and exemplars, will later serve to enrich Kuhn's notion that young scientists adopt the exemplars of their elders via a socialization process. In the meantime, it will be assumed that we are dealing with a mature member of a particular scientific community who, by socialization, has come to assimilate the sum total of knowledge available to him/her within the context of that community. It is this sense, I believe, which Kuhn has in mind when he speaks of exemplars as <u>concrete</u> puzzle solutions, but it is only one of the forms a schema may assume. In this way, then, both the notion of exemplars and the schema theory may be said to provide equivalent models for the organization of knowledge (i.e., provide conceptual categories). However, it is contended that the

function of exemplars in solving problems is but a function of human cognition at large. This is to say, that when applied to problem solving (an example of human cognition), the schema theory makes the same claims as Kuhn's theory of exemplars: that new problems are solved on the basis of established problem categories. Furthermore, the schema theory provides a more coherent picture of the scientists' cognition as it can account for the evolution of immature problem categories into exemplars.

Before turning to an empirical investigation of these contentions, namely, that the schema theory provides problem categories which serve as models for the solution of new problems and the evolution thereof, it will be necessary to include Kuhn's "learned perception of similarity" in this discussion. It will be recalled that this "learned perception of similarity" is the process whereby a new problem is fitted to a particular exemplar on the basis of a perceptual similarity. Thus, for Kuhn's "learned perception of similarity" to be redefined in light of the schema theory, the latter must be capable of explicating a process which mediates new problems to their corresponding exemplars prior to any criterion which is more extravagant than a perceptual similarity.

To begin, Kuhn's assertion that new problems are solved on the basis of a simple perceptual similarity between the new problem and an older, established problem is analogous to the act of comprehension as outlined by Rumelhart et al. (1977). For instance, both comprehension

and Kuhn's "learned perception of similarity" refer to the mediation of environmental stimuli by the appropriate cognitive category (schema or exemplar, respectively), whereby it is interpreted. For Rumelhart et al. (1977), comprehension occurs when a schema is instantiated, i.e., when objects in the environment, or from memory, are compatible with, and thus, capable of binding with, the corresponding variables in a particular schema. Then, once this schema becomes instantiated, the knowledge base associated with the concept that the schema represents can be accessed. Thus, to superimpose Kuhn's duck-swan-goose analogy, which was presented in the previous section, on this comprehension process, one could suppose that little Johnny's duck-schema, for instance, was composed of variables that corresponded to the duck's body size, and length and curvature of its neck. These variables, in turn, were shaped by Johnny's elders. Any additional information pertaining to Johnny's concept of duck (e.g., habitat, mating habits, coloration) would likely be stored in Johnny's memory as part of the knowledge base associated with his duck-schema. Similar schemas would also be constructed, out of modification or restructuring of a more general bird-schema, for swans and geese. In this way, Johnny's "perception of similarity" would evolve around fitting a particular waterfowl with a schema whose corresonding variables (e.g., body size, length and curvature of the next) show the greatest fit with those of the bird. Only after the dimensions from the bird and the variables from the schema

were bound would the schema become instantiated, and the knowledge base accessible. Any criterion of similarity, then, such as "all swans are white" would likely only be accessible after the initial perception of similarity was made. This example would appear to be analogous to Kuhn's notion that a "learned perception of similarity" proceeds prior to any logical or psychological analysis, for such analysis could occur only after the schema (or exemplar) was instantiated.

Up to this point in the discussion there has been no empirical verification of the contentions previously laid out. It will be the task of these investigations to yield concrete evidence as to the nature of schemata in the comprehension of problems. Such a process has been shown to be equivalent, at least hypothetically, to Kuhn's "learned perception of similarity" and his related notion of exemplars. Thus, it must be shown that schemata provide exemplary problem categories and that the "similarity" between a new problem and these older problem categories precede any logical or psychological analysis of the problem, in this case, formulating the problem for solution. To be sure, such evidence, although scarce, already exists in the literature. For example, Hinsley et al. (1978) conclude that the "schema approach" constitutes at least one of the processing strategies which humans employ in the comprehension of algebra word problems. This approach, as might be inferred, is characterized by "major decisions" (p. 90) made early by the problem solver in the process of comprehension, and also by the "importance of semantic knowledge" (p. 90).

In other words, the schema approach asserts that the problem solver must categorize the problem (i.e., make a "major decision") early in the course of solving it, and have a knowledge base (i.e., "semantic knowledge") stored in memory, which lends crucial information towards the problem's solution in order for the problem to be comprehended (i.e., solved).

The first experiment in the Hinsley et al. (1978) study was designed to test the basic hypothesis that if a "schema approach" is crucial to comprehension, then it will guide the subject to categorize algebra word problems into problem types (e.g., area, work, probability). The results obtained in this initial study corroborated this hypothesis. It was found that, when asked to sort 76 algebra word problems into problem types, subjects could recognize at least 16 problem categories. However, because this study did not preclude subjects from using criteria such as solution formulations to sort the problems, a second study was designed.

In this second experiment, it was hypothesized that if subjects could identify a problem type in the course of reading it, then it could be ascertained that subjects categorize problems prior to formulating them for solution. In other words, a problem-schema must first be instantiated before the knowledge associated with its solution can be accessed. Again, the results supported the hypothesis. "Averaged over nine ~~months~~ PROBLEMS, half of the subjects categorized the problem correctly after hearing less than one-fifth of the text"

and "for three of the problems (one each out of the categories of physics, DRT, and triangle), 81% of the categorizations were correct when only the initial noun phrase had been presented (Hinsley et al., 1978, p. 96). For example, a problem may have been correctly categorized as a "physics" problem after hearing only, "The speed of a falling body ..." Furthermore, in addition to categorizing the problem, some subjects were able to "describe the problem type, give an instance of the problem type, and specify what sorts of information they expected to receive and what questions they would be asked" (Hinsley et al., 1978, p. 77). Thus, it was concluded that individuals can and do categorize algebra word problems into characteristic types, and that this categorization may occur as early as the initial noun phrase, suggesting that problem categorization occurs prior to solution formulation. In this way, it may also be concluded that Kuhn's notion of a perceptual similarity (i.e., that a new problem can be "seen" to be similar to an older more established problem without analyzing it) and the related notion of exemplars (i.e., that prototypical problem categories exist) are equivalent to, and supported by, the schema theory.

But what about the "learned" component of this perceptual similarity? Kuhn himself offers little insight into the cognitive evolution that an individual undergoes in becoming a mature member of a scientific community. For instance, at what point in an individual's scientific career is he/she considered to be a member? Kuhn only stipulates

that members act in an unproblematic manner, sharing goals, professional judgments, perceptions and, as indicated in the previous section, problem categories. It is in regard to this latter stipulation, problem categories, that I am most interested. Schemata have the capacity to expand (by increasing the knowledge base), undergo modification and/or become restructured. Given these capabilities, it would be reasonable to assume that some changes in schemata occur that become associated with the problem field of a scientific community, either during the course of socialization or scientific education. Indeed, Chi et al. (1981) state that expert-novice differences in solving physics problems "may be related to poorly formed, qualitatively different, or non-existent categories in the novice representation" (p. 122) of the problem. In short, it will be the task of this section to shed some light on this issue, namely, the evolution of problem categories as an individual becomes more socialized into a scientific community (e.g., from undergraduate to Ph.D.). The Chi et al. (1981) studies will be instrumental in reaching this end.

The first experiment in the Chi et al. (1981) study was designed to determine the kinds of categories that novice (e.g., undergraduate) and expert (e.g., Ph.D student) physicists would generate when confronted with twenty-four basic physics problems. In general, there were no quantitative differences between the number of categories generated by the two groups (8.4 for the experts and 8.6 for the novices). On the basis of qualitative analysis, however, distinct

differences appeared. For example, there is little overlap between expert and novice categories (only five of twenty categories). Upon closer analysis, Chi et al. (1981) find that the novices categorized on the basis of surface features of the problem. In other words, the novices categorized on the basis of (a) the objects referred to in the problem (e.g., a spring, inclined plane); (b) the literal physics terms mentioned in the problem (e.g., friction, center of mass); (c) the physical configuration described in the problem (i.e., relations among physical objects such as a block on an inclined plane). On the other hand, it appeared that the experts categorized according to the major physics principle (e.g., Law of Conservation of Energy) governing the solution of each problem, or the "deep structure" of the problem. Thus, the results of this first study indicate that the categories into which experts and novices sort problems are qualitatively different.

The objective in the next experiment was to investigate the "basic approach," or solution methods that experts and novices would apply to the problems, and the identification of features in the problem statement which led to this "basic approach." First, it was found that, for experts, a "basic approach" was the major principle (e.g., Conservation of Energy) that they would apply to solve the problem. Intersubject agreement was nearly perfect among the experts with only three of the twenty problems leading to incongruent solution methods. The novices, however, were unable to produce any but the

most general kind of abstracted solution method. When asked to develop and state a "basic approach" they did one of two things: "They either made very global statements about how to proceed ... or they would attempt to solve the problem, giving the detailed equation sets they would use" (Chi et al., 1981, p. 142). Second, upon analysis of the subjects' protocols, it was determined that the kinds of features mentioned as relevant by the novices were different from those identified as relevant by the experts. For example, the relevant features selected by the novices were again literal objects and terms which could be identified in the problem statement (e.g., friction, gravity), whereas, the relevant features identified by the experts were characterized as descriptions of the states and conditions making up the physical situation described by the problem (e.g., before and after situation, no external forces). Because these latter features were not explictly stated in the problem, Chi et al. (1981) referred to them as "second-order features." These "second-order features" led the investigators to speculate as to which of the "first-order features," the explicit problem statements, led the experts to their abstracted descriptions. Chi et al. (1981) found a large overlap in the keywords selected by the experts and novices with the only apparent difference being that experts tended to identify fewer sets of words as relevant to their judgment, as compared to novices. However, "almost always, the keywords chosen by the experts are subsets of those chosen by the novices" (Chi et al.,

1981, p. 144).

In summary, the Chi et al. (1981) studies indicate that while both expert (Ph.D student) and novice (undergraduate) physicists were able to classify basic physics problems into the same number of categories, the nature of these categories differed. For example, the experts built categories on the basis of the underlying physics principle whereas the novice categories were constructed on the basis of the literal features of the problem statement. Finally, although both experts and novices attend to the same features of the problem statement, for experts, these "first-order features" are transformed into abstracted states and conditions called "second-order features." The "first-order features" remain literal to the novices. Thus, if the members of a scientific community share the same problem categories (i.e., exemplars) as Kuhn would assert, then on the basis of these findings, might we conclude that novices are non-members of the physics community? At first glance, one might answer yes. But perhaps Kuhn's notion of a problem category (i.e., exemplar) and its relation to the scientific community needs refining. To do so, first it will be necessary to present another experiment from the Hinsley et al. (1978) study.

This experiment involved the influence of different schemas on the categorization of the same problem. To test this influence, a standard algebra work problem was altered in two ways hopefully to strain out different schemata. For example, these alternations

entailed the introduction of irrelevant material into the problem and the addition of a second theme which would suggest an alternate but incorrect problem categorization. Out of the six subjects who participated, half attended to the extraneous theme and thus categorized the problem incorrectly, whereas the other half attended to the relevant theme. These results were interpreted to indicate that there were two schemas which subjects could have used as templates in formulating the ambiguous problem. Hinsley et al. (1978) conclude that "the schemas directed what the subject attended to in the problem, what information he regarded as relevant, and even what errors he made in reading the text" (p. 103).

Hence, because both the experts and novices in the Chi et al. (1981) experiments attended to the same features of the problem statement, would it not be reasonable, assuming Hinsley et al. (1978) is correct, to maintain that they were indeed employing the same problem categories? If so, then the novices could be considered members of the physics community, and Kuhn's notion of exemplar, as it relates to socialization would be in need of articulation. For as Kuhn states, the exemplars themselves are what the students of science learn, but the implication which arises here is that as one gains a greater knowledge base within the community for a particular schema, as a function of time, one's representation, solution and interpretation of the problem are likely to be altered (e.g., become more abstract), while still maintaining the same

basic problem schema. In other words, can one learn a "perception of similarity" between a new problem and an exemplar but still solve it differently than one's elders? Does Kuhn wish to confine his notion of exemplar to the representation and solution methods characteristic of experts? If so, then a student of science learns this perception of similarity, not between a new problem and an exemplar, but between a new problem and a precursory problem category, one which has not yet attained a sufficient knowledge base. In this way, Kuhn's notion of exemplar contains an ambiguity. For on the one hand, it refers to the arsenal of problem categories which the members of a scientific community employ to solve new problems, whereas on the other, it refers to the concrete puzzle solutions associated with the problem categories. Thus, on the basis of this ambiguity two implications arise in relation to the scientific community. For example, if by exemplar Kuhn means the former, then his notion of the scientific community must expand to include those in which socialization is incomplete (e.g., novices). However, much of the unproblematic behavior which so characterizes these communities' actions would be lost. On the other hand, if Kuhn chooses the latter, then his notion of exemplar, in relation to the socialization of an individual into a community, loses theoretical importance as it now presupposes expertise.

Conclusion

The assertion made at the outset of this paper, that cognitive psychology is in the position to collaborate with contemporary philosophy of science may now come to fruition. Within the scientific enterprise, for instance, there has been an epistemological trend towards understanding the limitations and validity of those who practice it (e.g., scientists) such that we may come to understand the limitations and validity of the scientific evidence which is generated. Indeed, as Quine (1969) remarked, "epistemology, or something like it, simply falls into place as a chapter of psychology and hence of natural science. It studies a natural phenomenon, viz., a physical human subject" (p. 82). As such, we noticed in this paper that Kuhn's "learned perception of similarity" and his related notion of exemplar fall into place as an example of this epistemological redefinition within the philosophy of science. But more importantly, we noticed that cognitive psychology (e.g., the schema theory) has converged with Kuhn in respect to their conceptions of cognitive organization and, thus, has provided the empirical analysis which Koch (1964) had envisioned. In short, within the context of this new epistemological framework we may now look to cognitive psychology for direction.

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